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# INFRASTRUCTURE COVERAGE OF THE URAL FEDERAL DISTRICT REGIONS: ASSESSMENT METHODOLOGY AND DIAGNOSTICS RESULTS[1]

*The article examines the infrastructure as one of the essential elements in the economic system. The authors consider the development stages of this concept in the scientific community and provide the opinions of a number of researchers as to the role and place of the infrastructure in the economic system. The article provides a brief genesis of approaches to describing the infrastructure and conferring its functions on individual branches. The authors emphasize the higher importance of infrastructure coverage with the economy transition to machine production. Two key methodological approaches are identified to describe the substance and content of the infrastructure: industrial and functional.*

*The authors offer their methodology of assessing the infrastructure coverage of regional-level territories. The methodology is based on identifying a combination of specific indicators the values of which can be used to evaluate the development level of individual infrastructure elements. The indicative analysis being the basis of the methodological apparatus helps make a judgment of any phenomenon by comparing the current observed values with the previously adopted threshold levels. Such comparison makes it possible to classify the observations by the «norm—pre-crisis—crisis» scale. An essential advantage of this method is the possibility of standardizing the indicators, or, in other words, bringing them to one comparable conditional value. Thus, you can get estimates for individual blocks of indicators and a complex assessment for the whole set in general. The authors have identified four main infrastructure elements: transport, communications, public utility services and healthcare. The methodology includes 21 indicators all together.*

*The test estimates based on the authors' methodology revealed the defects in the development of the Ural regions` infrastructure. The article provides a brief analysis of the obtained data with identifying individual indicators and areas.*

**Keywords:** infrastructure, infrastructure coverage, indicative analysis, Ural regions, economic security, economic growth, sustainable development, balanced development, regional economy, and regional policy

Infrastructure is an indispensable element of practically any integral social and economic system or its part. At the turn of 20th century, this term was first used in the analysis to describe the facilities and structures needed for normal functioning of armed forces. In the second half of the 20th century, infrastructure became the object of research in the economic theory. At that time, its role and value for the market economy grew considerably. Now, infrastructure is an essential element of the market economy and is inherent in all economic systems — it helps to improve the production relations and to master the life space in the society.

K. Marx, F. Engels, and other classics of economic thought viewed the infrastructure as an auxiliary element in the development of social relations, and the social overhead capital was used as a synonym. K. Marx used the categories that by their social and economic content corresponded to the infrastructure: "general terms of the social production process," "general labor conditions" [1].

According to the representatives of the Marxist political economy, the reason for viewing the infrastructure as an independent economic sphere was social labor differentiation, due to which the "social production process was broken up into individual independent types of labor activities interrelated by regional exchange" [2]. In the process of further research, two areas emerged in the system of social reproduction within the scope of general labor division: primary production and auxiliary production — infrastructure. The infrastructure had such priority objectives as creating conditions for primary production and satisfying the society's needs.

Currently, the term "infrastructure" has no established accepted definition. Its interpretation is gradually expanding to include the social sphere and the service production system. The concept can be fully opened up through describing its functions. In examining the infrastructure in terms of geography, the functional approach implies studying the way it functions and the effect it has on the social, economic and spatial development of the regions. S.A. Tarkhov offers to distinguish between the territorial and spatial infrastructure development [3]. The term "territorial development" reflects environmental, social, economic and other changes in a specific territory, and the term "spatial development" refers to the changes in the infrastructure structure.

In regional development, A.A. Tkachenko proposes to distinguish between "substantive" (economic, social, cultural, etc.) development and spatial development of a territory that "involves changes in the configuration and spatial structure of the territory itself and its constituent systems and complexes." Similarly, territorial (regional) management should distinguish between management of the "substantive" (social, economic, etc.) development and management of the spatial development" [4].

The USSR had quite a developed information infrastructure characterized by high information culture. It reached its climax in the second half of the 20th century when the State Scientific and Technical Information System (GSNTI) was created [5]. This system is characterized as a fine-tuned stable mechanism focused on the needs of the Soviet economy. At the times of the USSR, the information infrastructure corresponded to the economic model the country had at that period. Further on during the years of "perestroika", this model turned out inconsistent with the new economy, as there was no main consumer anymore — the state ready to cover all costs, while the overall market reduction led to the emergence of new demands and new needs. The need for transforming the system is quite clearly described in the work of O.V. Kedrovsky [6]. Analyzing the social and economic challenges of the early 90's of the past century, identifying weak points and forming the areas for further development of the information system, O.V. Kedrovsky points out to a number of peculiarities that are still actual:

1. "Despite the variety of ownership forms in the information industries of the western countries, the overall balance evidences that these industries have a much higher share of state ownership than the material production industries" [3].

2. "Special-purpose information companies cannot adequately meet the challenge of collecting and distributing knowledge primarily because they can cover only part of the documents that contain new knowledge" [3].

3. "Not more than 10% of information about research achievements is distributed through the information systems" [3].

4. "Low susceptibility of the economy to achievements" [3].

5. "A purely commercial approach is not acceptable" in spreading the information system [3].

At the end of the 20th century, state urban planning was replaced by a pseudo-organization of urban structures based on market economy processes — that was the end of urbanization in Russia giving way to chaotic development of the existing cities. As a result, the methodology of harmonious design and development of urban infrastructures was lost, including the systems of public services [7].

Thus, we can say that the infrastructure has gone through several development stages:

Stage I. Early 20th century — birth of the "infrastructure" concept to denote the facilities and structures that ensure normal military activities.

Stage II. Middle 20th century — the infrastructure becomes an integral part of market economy and is inherent in any economic systems.

Stage III. Late 20th century — transformation of the infrastructure systems based on the market economy processes; the end of the urbanization century in Russia and the beginning of a chaotic development of existing cities.

The functioning of modern economy (in particular its efficiency, competitiveness, dynamism, etc.) to a large extent depends on the infrastructure component [8–11]. Let us mention two key methodological approaches describing the substance and content of the infrastructure:

1. The industrial approach described in the works of E. B. Dvoryadkin and E. A. Sapozhnikov [12]. It defines the infrastructure as a combination of economy sectors ensuring general conditions for reproduction.

2. The functional approach developed by Y. Y. Suslova and O. A. Yabrova [13]. The authors determine the infrastructure as a special set of functions intended to address organizational and social issues.

The level of the infrastructure completeness and comprehensiveness affects the character and the specifics of the industrial and territorial organization of public production, as well as the living conditions in the regions. The demographic, social, economic and other distinctive territory features are to a large extent due to regional and infrastructure peculiarities. Insufficient development of infrastructure areas has an adverse effect on the development of the region's production powers and causes additional costs for an adequate production base. That is why the target social and economic development programs must assess the availability of infrastructure components within a territory, the so-called "infrastructure potential."

Local territorial infrastructure adequate to local conditions is created in the administrative districts and in medium and small communities. The potential of infrastructure development is constituted by a number of factors determining both social-economic and spatial specifics of its functioning.

The potential of a territory is a combination of material facilities intended to service the production, the population and the society in general and capable of satisfying various needs for tangible and intangible benefits and services within such territorial community. Potential characterizes the ability of a territorial system of services to perform its key function — satisfying various public and production needs for services. Therefore, the territory's infrastructure potential should be taken into account. It should also be mentioned that efficient use of infrastructure potential involves production and economic indicators, as well as social ones. Satisfying socially significant public needs is one of the infrastructure goals.

At the micro and meso levels, the infrastructure coverage much depends on the activities of local authorities and may be an important element of regional policy. It can help to address the challenges of developing remote, rural and other depressive territories by combining market and administrative management methods, applying a comprehensive approach to the utilization of resources, and expanding inter-regional relations.

Currently, efficient country development involves improving its infrastructure component and increasing its share in the region's economy. Earlier, at the times of planned economy, a disproportion arose between the development of production industries and the infrastructure coverage resulting from the underestimated role of the latter. Financing was insufficient, and the role was viewed as secondary after the primary production. Such state of affairs worked well in the medieval period when the industry was poorly developed and less demanding for a developed infrastructure. The economic order existing at that time enabled small separate manufacturers to operate with an insignificant share of infrastructure in the current understanding of this term. However, the technical revolution and the development of machine production gave rise to the demand for infrastructure industries. It was after labor was divided into separate types of activity and individual narrow industrial activities were distinguished that an economically reasonable need arose for the development of the infrastructure component (roads, utilities, communications, etc.) [14]. Modern-day research considers such infrastructure facilities as one of the elements of economic growth and social welfare [15–17].

Before turning into an independent area of public production, the infrastructure went through a number of stages determined by significant events in the social labor division. The first major labor division — trades other than agriculture. The second labor division in the society resulted in the emergence of cities. It contributed to the exchange of products between village and city, leading to the development of infrastructure facilities. The third social labor division caused a separation of the trade from industry and agriculture. It led to further growth of product exchange by involving new territories into the economic turnover, which required an expansion of the infrastructure sector.

A new type of infrastructure is market infrastructure. With the development of a market mechanism, the country's economy needed a specialized type of activity to satisfy the needs of individual markets — an organized system to meet demand and proposal. The appearance of the market led to the emergence of new organizations and institutions ensuring its civilized functioning [18].

Thus, it can be concluded that according to modern-day requirements the market infrastructure plays a crucial role in the social and economic development of the region and the restructuring of the regional economy.

The methodology for assessing the regional infrastructure offered by the authors is based on the indicative analysis. Such approach proved effective in assessing various phenomena in the social and economic systems of Russian regions [19–21].

The methodology is based on identifying a combination of specific factors termed indicators the values of which can be used to assess the development of individual infrastructure elements. These indicators are grouped by the infrastructure elements characterizing its individual components and forming blocks of indicative factors.

The indicators included in an individual block differ substantially in terms of quantity, type and methods of their setting. For a more comprehensive description of a situation, synthetic indicators are also applied in certain areas that are a combination of a certain number of individual indicators. Such hierarchical structure and the appropriate indicators enable a deeper analysis of the conditions required to ensure the infrastructure coverage of a territory and to identify individual threats to its social and economic development caused by a certain structure or specifics of the existing infrastructure industry prevailing in specific territories. Specific indicators to be used for the methodology are selected from the perspective of describing the condition and capacity of an infrastructure element, as well as its efficiency and security. Below is a list of identified indicators and indicative blocks.

1. Transport block.

1.1. Synthetic indicative factor to describe the territory coverage with transport routes.

1.1.1. Motor road density indicator, km/thousand km2.

1.1.2. Railway density indicator, km/10 thousand km2.

1.2. Synthetic indicative factor of the transport infrastructure efficiency.

1.2.1. Car infrastructure performance indicator, ths t/km.

1.2.2. Railway infrastructure performance indicator, ths t/km.

1.3. Traffic accidents per road unit indicator, instances/ths km.

2. Communications block.

2.1. Synthetic indicative factor of communication services available to the public.

2.1.1. Residential telephones, pcs per ths people.

2.1.2. The number of connected subscriber mobile radio-telephone devices, pcs per ths people.

2.2. Synthetic indicative factor of telematic and data networking services.

2.2.1. Number of active subscribers of fixed broadband Internet access, subscribers/ths people.

2.2.2. Number of active mobile radio-telephone communication subscribers using Internet access services, subscribers/ths people.

2.2.3. Volume of information transmitted from (to) the subscribers of the reporting operator upon Internet access, PByte.

2.3. Synthetic indicative factor of communication coverage.

2.3.1. Public TV and radio broadcasting coverage, % of the region's total population.

2.3.2. Specific weight of organizations using information and communication technologies in the total number of surveyed organizations of the respective Russian region, %

2.3.3. Number of personal computers, units per 100 employees.

2.3.4. Specific weight of organizations having their own website in the total number of surveyed organizations of the respective Russian region, %.

3. Block of utility services available to the public.

3.1. Indicator of per capita electricity consumption in the territory's utility sector, kWh/person.

3.2. Indicator of per capita heat consumption in the territory's utility sector, Gcal/person.

3.3. Utility lines wear factor, %.

4. Healthcare unit.

4.1. Indicator of hospital beds per 10,000 people, bed/10,000 people.

4.2. Synthetic indicative factor of available medical personnel.

4.2.1. Indicator of physicians available to the public, person/10,000 people.

4.2.2. Indicator of mid-level medical personnel available to the public, person/10,000 people.

4.3. Capacity of outpatient policlinics per 10,000 people, visits per shift.

4.4. Indicative budget healthcare expenses / GRP ratio, %.

The key concept in determining the availability of an individual infrastructure element associated with the respective indicative factor is the threshold indicator values. These are the indicator values marginal for adjacent crisis levels for the respective indicator. The authors identify three basic levels of the territory condition in terms of security — normal (N), pre-crisis (PC) and crisis (C). Two threshold values for each indicator that distinguish these three zones may be determined using both the objective and subjective methods. One of the most efficient objective methods is discriminatory analysis. There are mathematical tools [22, 23] that may be used to obtain the target threshold values by statistical processing of learning samples of monitored objects with the known indicator status. However, not all indicative factors have such an option, and in most cases expert analysis methods are to be used.

The experience of analyzing the dynamic changes in the situation showed that to ensure timely and proactive response to the changes in the system condition and to take management measures, the above two threshold levels are not enough. Therefore, another three gradations of security statuses were introduced for both pre-crises and crisis conditions: pre-crisis (initial (PC1), developing (PC2), and critical (PC3)) and crisis (non-stable (C1), threatening (C2), and emergency (C3)). The limited volume of samples to obtain sufficiently valid threshold indicator values allows using statistical methods only to determine the basic threshold values of indicative factors. As to additional threshold values for finer gradation of crisis levels, it is expedient to apply a uniform scale.

As per the adopted approach of assessing the infrastructure component, Russian regions were divided into territorial districts based on the threshold values of power security indicators and thresholds were determined. At the next stage of the complex methodology, the estimated indicative security factors, expressed in various named units, are transferred into a single non-dimensional form. This stage is a standardization of indicative factors where the differences of the above two threshold indicator values—crisis and pre-crisis—are taken as their basic values. At the next stage, the infrastructure coverage is assessed by indicative blocks with an overall evaluation of each infrastructure territory. To that end, the method of scalarization (convolution) of standardized indicative factors subject to their weight values.

The authors estimated the infrastructure coverage under the developed methodology based on four basic components that describe the development of transport infrastructure, the availability of communications, the sufficiency of basic utility services and the availability of a developed healthcare system in the region.

In the first block of the transport infrastructure, in 2013 the situation with roads in the Ural Federal District (UFD) can be described as unsatisfactory with the Urals road density of 38 km/1,000 km2, which is considerably less than in the European part of Russia. The situation in the Chelyabinsk Region is better (187 km/1,000 km2), then come the Sverdlovsk and Kurgan Regions with approximately equal state of affairs (about 120 km/1,000 km2), while the Tyumen Region falls behind in road construction due to natural reasons, and its level of 14 km/1,000 sq. km reduces to 2.8 km/1,000 km2 in the Yamal-Nenets Autonomous District (YNAD). However, the dynamics of changes are more than positive. Since 2000, the length of hard-coated motor roads has grown two-fold in the Sverdlovsk and Chelyabinsk Regions and in the Ural Federal District in general. The Tyumen Region and its districts demonstrate still higher dynamics — a 2.5 to 3-fold growth, however here we have the effect of a small base, or, in other words, weak initial road coverage.

Unlike motor roads, railway transport coverage is normal in most territories, except for YNAD. In this autonomous district, the railway density is low about 6 km/10 ths km2, which can well be attributed to difficult construction in permafrost.

In 2000–2013, the efficiency of using the car infrastructure of territories expressed in traffic volumes per unit of motor road network reduced. It can be explained by increased road network, on the one hand, and reduced road traffic, on the other hand. In UFD, road traffic per kilometer of motor roads reduced from 17.2 ths t/km in 2000 to 10–11 ths t/km in the pre-crisis 2007–2008 and 6 ths t/km in 2013. In the period in question, more consignors shifted to railway transport the traffic flows of which grew. Thus, if in 2000 the traffic volume per unit of road in UFD was about 14 ths t/km, in the pre-crisis 2007–2008 it amounted to 18–19 ths t/km, and by 2013 it reached 22 ths t/km. All UFD regions demonstrated a similar tendency both in terms of changes in traffic volumes and in terms of the preferred kind of transport.

The road accident indicator per unit of motor roads characterizes the safety of the transport infrastructure. Taking motor traffic accidents alone is due to a substantially higher (2–3-fold) rates of car accidents than those of railway or other transport. In UFD, the indicator tended to increase in 2000–2004 from 450 to 650 instances per 1,000 km of motor roads, and reduced significantly in 2009–2013 to 250 instances per 1,000 km. Such dynamics can on the one hand be attributed to the growth of the car fleet and the enactment of the mandatory third party liability insurance law, which increased the ratio of registered accidents, and on the other hand the imposition of stricter penalties in the recent years for the violation of traffic rules enhanced the drivers' discipline and resulted in fewer traffic accidents.

The transport component can be generally described as follows: normal in the Chelyabinsk Region, initial pre-crisis levels in the Kurgan and Sverdlovsk Regions, and poor coverage in the Tyumen Region and its autonomous districts.

The communications infrastructure component was assessed based on the communication services available to the public, the level of telematic and data networking services, and the communications coverage.

The communication services available to the public were assessed based on whether inhabitants of the region have residential telephones and connected mobile radio-telephone communication subscriber devices. The first indicator is characterized by a low extent of line communications among the public with ambiguous dynamics identified within the interval in question: from 2000 to 2008–2010 there was a stable growth by 50% on average in UFD (by up to 100% in the Kurgan Region) with a subsequent reduction in the number of house telephones. Such indicator changes are common for all UFD territories without any exceptions. The reasons for such dynamics include the increased line communication tariffs, and the higher availability of mobile radio-telephone communication services and devices. The indicator of the number of connected mobile radio-telephone communication subscriber devices in the period in question grew drastically. If at the beginning of the 2000s, a mobile phone was a luxury, gradually with the development of the telephone network and the reduction of ownership cost, more and more people used this kind of communication. By 2006–2007, the number of connected subscriber devices exceeded the population (as many people used two or more cellular phones) resulting in the refusal of stationary devices. Further on, the number of subscribers continued to grow, though at lower rates.

In general, the availability of communication services is assessed as sufficient only in the Yamal-Nenets Autonomous District, while Tyumen Region and the Khanty-Mansiysk Autonomous District (KMAD) are characterized by average pre-crisis levels. The situation is worse in the Kurgan, Sverdlovsk, and Chelyabinsk Regions, where lower household incomes make people save on line communications.

The development of telematic and data networking services was analyzed by three indicators: the number of active fixed broadband Internet subscribers; the number of active mobile radio-telephone communication subscribers using the Internet services; the volume of information transmitted from (to) the subscribers of the reporting operator upon the Internet access.

From 2000, the number of active fixed broadband Internet subscribers grew substantially. Currently, the Chelyabinsk Region has the highest wire Internet coverage (over 200 subscribers per thousand people), and the Kurgan Region is the least covered (154 subscribers per thousand people).

The estimation of the active mobile radio-telephone communication subscribers using Internet access services is similar to the above: since its emergence on the market in the 2000s; this service has been used more extensively. To date, YNAD, KMAD, and the Sverdlovsk Region have the most subscribers (over 1,000 subscribers per thousand people), while the least number of subscribers is in the Kurgan Region (591 subscribers per thousand people).

The volume of information transmitted from (to) the subscribers of the reporting operator upon the Internet access grows with the distribution of household digital technologies. With the growing number of fixed broadband Internet subscribers, distribution of digital TV, etc. the value of this indicator grows year by year. Currently, the average volumes of Internet traffic in UFD are 133 Gb per thousand people. However, in the Tyumen Region this indicator is low (41 Gb per thousand people), which in view of the high preceding indicators can be attributed to insufficient communication bandwidth.

The level of telematic and data networking services is generally assessed as normal in KMAD and YNAD, while the rest territories and the Ural Federal District are generally at the initial pre-crisis stage.

The communications level is reflected by the indicator of TV and radio coverage. The condition of the UFD regions is diagnosed as normal, with the average level in UFD of 98–99%.

In 2000–2013, the communications module generally demonstrated positive dynamics. From the 2000s, the situation in the Tyumen Region and its autonomous districts improved considerably (from the crisis to normal or initial pre-crisis stages), while the Kurgan, Sverdlovsk, and Chelyabinsk Regions changed to a lesser extent (from the crisis to pre-crisis stage). The situation is generally caused by the low indicator of residential telephones.

The utility sector was assessed by the indicators of per capita electricity and heat consumption and the degree of utility lines wear.

The estimated electricity consumption indicator for the utility sector revealed problems in the Kurgan Region only where this level is stably low though has a tendency towards growth, and in 2013 it was 734 kWh/person with the average level in UFD of 1,093 kWh/person. The situation is similar with heat consumption. In 2013, the Kurgan Region was supplied at 2.1 Gcal/person, while the average value for UFD is 5.6 Gcal/person.

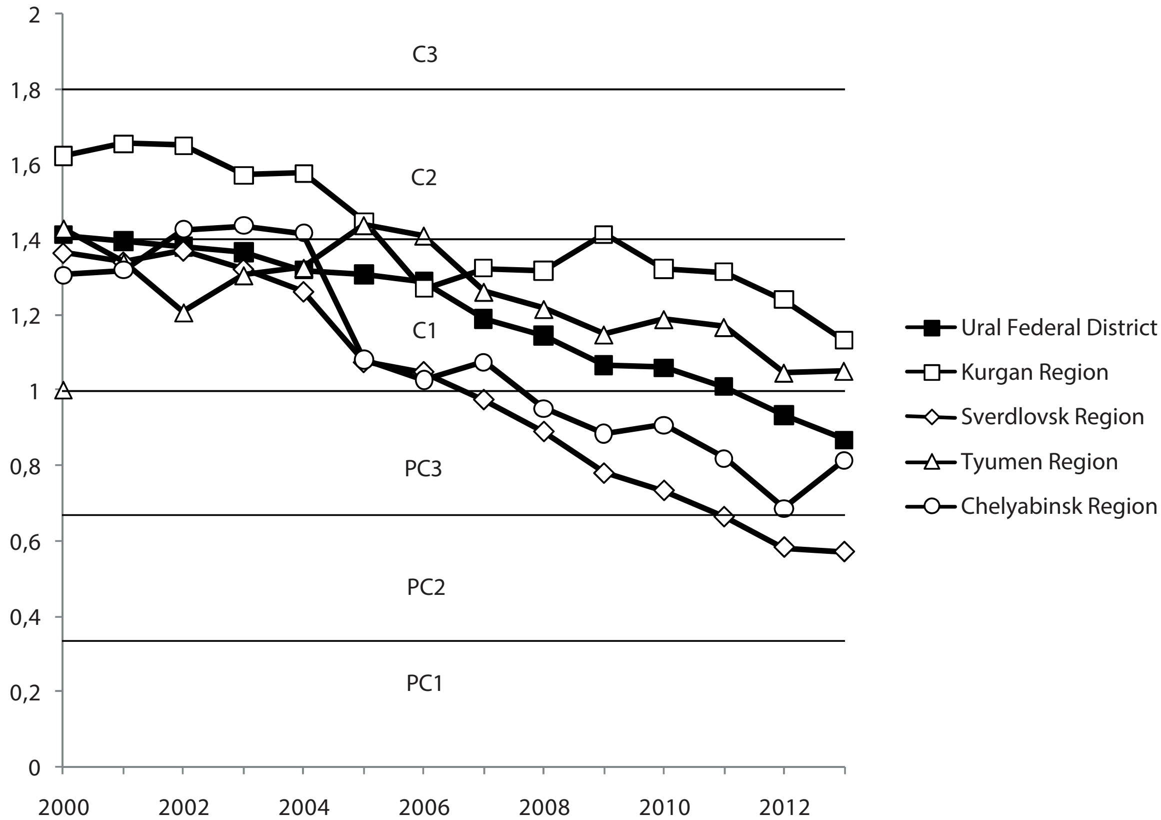


**Fig.** *Estimated infrastructure coverage in 2000–2013 for the UFD territories*

A challenging situation is with the utility lines wear indicator. In the Kurgan Region, the estimated wear level is about critical 70%, while the other territories have the values ranging from 30% in YNAD to 47% in the Chelyabinsk Region.

In general, the utilities sector is assessed as critical in the Kurgan Region and is at the initial pre-crisis stages in other regions (save YNAD where the situation is normal).

The development of the healthcare system was assessed based on the availability of hospital beds and medical personnel, the capacity of healthcare institutions, and the volumes of healthcare financing.

The availability of hospital beds per 10,000 people is not satisfactory for any UFD territory. The worst indicators are in the Tyumen Region, KMAD and the Chelyabinsk Region (78–88 beds/10,000 people), while other territories have a bit better indicators. There is a stable general decrease in the number of hospital beds that in 2000–2013 reached 30%.

The low availability of medical personnel is also a problem. With the normal quantity of mid-level medical personnel, there is a deficiency of physicians in all territories, except for KMAD. As compared to 2000, the problem of the Tyumen Region has become not so acute, while the improvements in the Kurgan and Chelyabinsk Regions are less obvious. There were no significant changes in the Sverdlovsk Region.

The indicator of the outpatient clinics' capacity has normal values in the Tyumen Region and its districts and is practically normal in the Sverdlovsk Region. Low levels are observed only in the Chelyabinsk and Kurgan Regions.

The ratio of the budget expenses to the gross regional product was falling until 2006–2009 in various territories and then started to grow. The maximum indicator value is found in the Kurgan Region, and the minimum one in the Tyumen Region, which can well be attributed to the various budgets of these regions.

The dynamics of changes in the assessments of the UFD regions for the infrastructure block is provided in the picture. The obtained positive dynamics is chiefly formed by the indicators of the transport sector and the communications sector.

The research lets us conclude that the development of the infrastructure component in the Ural Federal District is not sufficient. The motor road density in UFD is low even in comparison with the European part of the country, where the value of this indicator is 2 to 3-fold higher. Moreover, the road network is poorly connected resulting in long transport runs and, naturally, additional costs.

The car accident rate is 250 traffic accidents per 10,000 km, which is a very high level. Individual UFD territories have serious difficulties with updating utility networks. Their increased wear adversely affects the reliability and efficiency of the heat and water supply systems. Most Ural territories have inadequate medical infrastructure — there are few treatment facilities, and there is a serious shortage of personnel. The above weak points can be overcome only in cooperation with local and federal state authorities. There must be systems for diagnosing the situation, evaluating the scenarios, working out a regulatory framework for the development of infrastructure facilities, and determining the sources of financing. The above measures will ensure safe development of the UFD infrastructure and will become a powerful factor to support the required rates of economic growth both within the district territories and in Russia in general.

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